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UNITED STATES ARMY
ENVIRONMENTAL HYGIENE
AGENCY

ABERDEEN PROVING GROUND, MD 21010

INTERIM REPORT
MIGRATION OF ^{14}C PERMETHRIN FROM IMPREGNATED MILITARY FABRIC
STUDY NO. 75-51-0351-82
DECEMBER 1981 - FEBRUARY 1982

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DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

Mr. Snodgrass/mhb/AUTOVON
584-3980

REPLY TO
ATTENTION OF
HSHB-LT-P/WP

16 JUL 1982

SUBJECT: Interim Report, Migration of ¹⁴C Permethrin from Impregnated Military Fabric, Study No. 75-51-0351-82, December 1981 - February 1982

Executive Secretary
Armed Forces Pest Management Board
Forest Glen Section, WRAMC
Washington, DC 20012

EXECUTIVE SUMMARY

The purpose, essential findings and conclusions of the inclosed report follows:

a. Purpose. The insecticide permethrin has been proposed for use as an impregnant in military fabric. The potential for chemical fallout onto the skin surface from the impregnated fabric was assessed using rabbits. Radiolabeled (¹⁴C) permethrin was combined with a commercial emulsifiable concentrate of permethrin for impregnation.

b. Essential Findings. After 7 days of continuous fabric wear by rabbits, 4.5 percent of the available permethrin from impregnated cloth had reached the skin surface. About 7 percent was recorded at 14 days and 8 percent after 3 weeks. No significant radioactive permethrin was recovered from specimens of internal organs.

c. Conclusions. The reported test system provided a maximum potential for fabric fallout of permethrin to skin. The deposition level when extrapolated to man would not be expected to cause toxic effects. Furthermore, industrial impregnation procedures would result in even less migration of permethrin from uniform surface to skin.

FOR THE COMMANDER:

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John F. MAZUR
LTC, MSC
Director, Laboratory Services



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USDA, ARS (Dr. Terrence McGovern)
USDA, ARS-Southern Region (2 cy)



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INTERIM REPORT
MIGRATION OF ^{14}C PERMETHRIN FROM IMPREGNATED MILITARY FABRIC
STUDY NO. 75-51-0351-82
DECEMBER 1981 - FEBRUARY 1982

1. AUTHORITY.

a. Memorandum of Understanding between the US Army Environmental Hygiene Agency; the US Army Health Services Command; the Department of the Army, Office of The Surgeon General; the Armed Forces Pest Management Board; and the US Department of Agriculture, Agriculture Research, Science and Education Administration; titled Coordination of Biological and Toxicological Testing of Pesticides, effective 23 January 1979.

b. Letter, Armed Forces Pest Management Board (AFPMB), 2 November 1981, subject: The Toxicological Testing of Candidate Pesticide Compounds, w/incl.

2. PURPOSE. The purpose of the study was to determine the rate and amount of migration of ^{14}C permethrin from impregnated military fabric onto the skin of rabbits. A section of impregnated fabric was dermally affixed to rabbits to maintain continuous contact for 7, 14 or 21 days. Deposition of ^{14}C permethrin on the skin was assessed by measuring extractable radioactivity. Excreta was monitored daily for absorbed chemical as well as selected tissues at necropsy.

3. BACKGROUND. The insecticide permethrin has undergone extensive evaluation as a cloth impregnant for the protection of military personnel from the bites of medically important arthropods. Recommendations as to the benefits of this uniform treatment over the currently available M-1960 repellent mixture are under review by the Armed Forces Pest Management Board. Toxicological questions have been raised regarding the potential of permethrin to be deposited on the skin surface as a result of short- and long-term wear of the impregnated clothing. Earlier investigations have concluded that very little of the chemical is actually lost to the skin surface as measured by chemical methods. However, to detect small amounts on the skin, it was determined that a radiolabeled permethrin formulation be used to impregnate fabric for animal testing.

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the US Army but is intended only to assist in
identification of a specific product.

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Study No. 75-51-0351-82, Dec 81 - Feb 82

4. MATERIALS.

- a. The ^{14}C -labeled cis permethrin; 1.04 $\mu\text{Ci}/\text{mL}$ in absolute ethanol; designated NRDC 148.
- b. The ^{14}C -labeled trans permethrin; 0.96 $\mu\text{Ci}/\text{mL}$ in absolute ethanol; designated NRDC 146. Both cis and trans isomers were radiolabeled in the methylene group of the alcohol moiety and contained a specific activity of 59.7 mCi/mM . Radiolabeled permethrin isomers were provided by The Wellcome Research Laboratories, Burroughs Wellcome Co., Research Triangle Park, NC 27709.
- c. The military fabric was provided by the Textile Research and Engineering Division, Individual Protection Laboratory, US Army Natick Laboratories. The fabric was designated as battle dress uniform fabric, woodland camouflage print, nylon/cotton twill: No. DAAK 60-C-0052.
- d. Permanone[®] 40 EC (Code 850.00, FE C75). Forty percent permethrin emulsion concentrate for fabric impregnation; cis/trans content - 43.4/56.6. Permanone 40 EC was provided by the Fairfield American Corporation, Medina, NY 14103.

5. ANIMALS. Twenty albino rabbits of either sex, weighing between 1.6 and 2.3 kg, were purchased commercially from Dutchland Laboratories, Inc., Denver, PA. Each animal was individually housed in a Wahmann stainless steel metabolism cage and identified by ear tattoo and cage label. A commercial laboratory diet, Purina Certified Rabbit Chow No. 5322, and water were available ad libitum.

6. METHODS.

a. The ^{14}C -labeled cis and trans isomers of permethrin were matched and combined with the cis/trans isomer proportions of the commercial Permanone 40 EC for fabric impregnation. The labeled emulsion, 46.66 mL, was evenly poured over a 2100 cm^2 piece of fabric and allowed to air dry. Forty-two swatches, measuring 6.25 x 8 cm, were cut for testing. Each 50 cm^2 swatch contained a calculated radioactivity of 20.19 μCi and mass of permethrin of 6.38 μg (127.6 $\mu\text{g}/\text{cm}^2$). Impregnation of the fabric was performed by the US Department of Agriculture (USDA) personnel at Gainesville, FL.

b. Rabbits were divided into three groups of six. The test period for each group was 7, 14 or 21 days. Two rabbits were designated as controls and had dermally affixed the unimpregnated fabric.

[®] Permanone 40 EC is a registered trademark of Fairfield American Corporation, Medina, NY 14103.

Study No. 75-51-0351-82, Dec 81 - Feb 82

c. One day prior to test start, the backs of each rabbit were closely clipped over the entire lumbar area. The clipped area was examined the following day and a patent skin area designated to receive the test fabric.

d. A 50 cm² swatch of impregnated fabric, was dorsally affixed to each test animal and covered by a larger piece of 3/16 foam sheeting. The covering was secured at the edges to the animal with adhesive tape. Following application (day 0) of the ¹⁴C-labeled impregnated fabric each animal was returned to its cage. Urine specimens were collected and measured daily and aliquots retained for radioactivity counting.

e. At the end of each test period (7, 14 or 21 days) animals were euthanized and the following specimens collected for radiocarbon measurement.

- (1) Blood
- (2) Liver
- (3) Kidney
- (4) Adrenal glands
- (5) Muscle, longissimus, from application area
- (6) Entire skin section of application area for absolute ethanol extraction.
- (7) Foam covering and adjacent adhesive tape for absolute ethanol extraction.
- (8) Test fabric for ethanol extraction.

Additional impregnated fabric swatches (not used in the animal tests) were measured for radiocarbon content before, during and at the end of the 21-day study period to assess uniformity of impregnation and stability. Methods for specimen collection/treatment, radiocarbon analyses and calculations of radioactivity were performed as described in Toxicology Division SOP, Radioisotope Studies, April 1981.

7. RESULTS.

a. The ¹⁴C-labeled permethrin fallout from impregnated fabric was calculated as the radioactivity recovered on or in the skin at the end of each test plus absorbed chemical appearing in urine throughout each study period. These values were compared to the projected impregnation rate for each 50 cm² swatch and later confirmed by extracting radioactivity from swatches not used in the animal tests. The mean extracted radioactivity from 12 random swatches measured 20.34 µCi per swatch or 100.7 percent of the calculated impregnation rate.

Study No. 75-51-0351-82, Dec 81 - Feb 82

b. The permethrin fallout from impregnated fabric dermally affixed to rabbits measured cumulatively 4.5 percent after 7 days, 7.3 percent after 14 days and 8.1 percent after 21 days of continuous wear ($5.83 \mu\text{g}/\text{cm}^2$, $9.35 \mu\text{g}/\text{cm}^2$ and $10.37 \mu\text{g}/\text{cm}^2$ respectively). See Table.

c. Maximal absorption/excretion of radiolabeled permethrin from impregnated fabric occurred 3 to 4 days following application and gradually declined thereafter. Only trace amounts of radioactivity appeared in urine at the end of 21 days.

d. Tissue and blood specimens collected at necropsy usually demonstrated the absence of internal radioactivity. No specimen contained more than 0.06 ppm of permethrin per gram of tissue analyzed.

8. DISCUSSION.

a. As a species, the rabbit generally exhibits the greatest absorption potential for topically applied chemicals when compared to man. Reportedly, a seven-fold difference favoring man may be expected for many compounds.¹

b. The contact of the test fabric to the rabbits' back should be comparable to areas of maximal contact in man, i.e., shoulders, buttocks and thigh. Fortunately, the anatomic regions of greatest absorption potential in man, the face, scalp and scrotum,² would not be in contact with impregnated fabric. Protection from the direct contact of the scrotal area should be afforded by an undergarment.

c. Of the projected methods for impregnation of military fabric with permethrin,³ the current test in animals simulated what might be expected in a field situation where the uniform is dipped in a permethrin emulsion. The alternatives are:

(1) Impregnation during the industrial dye bath heat process before the fabric is cut and sewn or,

(2) The pressurized spraying of the outer uniform surface with diluted permethrin in the field.

d. The dipping method in field use as well as the saturation technique used in the current test presents maximal permethrin residue available to the skin surface. This method further compromises accurate projections regarding concentration of permethrin per cm^2 of fabric. Our tests indicate a variation of nearly 50 percent can occur among randomly selected swatches by the saturation method.

TABLE. FATE OF PERMETHRIN FROM IMPREGNATED FABRIC DERMALLY APPLIED TO RABBITS

		DAY 7 μg/cm ²	%*	DAY 14 μg/cm ²	%*	DAY 21 μg/cm ²	%	MEAN μg/cm ²
A.	CONTROL FABRIC	106.0†	135.15 +31.78	88.3	112.73 +19.02	102.8	131.18 +20.22	100.7
B.	TEST FABRIC	78.6	100.26 +12.24	62.6	79.84 +11.70	72.9	92.98 +16.29	128.55 +27.99
C.	COVERING	9.5	12.17 +2.38	11.3	14.47 + 6.73	21.2	27.04 + 3.28	
D.	SKIN-APPLICATION SITE	1.9	2.53 + 0.98	2.8	3.63 + 0.85	2.7	3.44 + 2.80	
E.	ABSORPTION-CUMULATIVE URINARY EXCRETION	2.6	3.30 + 1.57	4.5	5.72 + 2.59	5.4	6.93 + 3.43	
F.	TOTAL FALLOUT (D+E)	4.5	5.85	7.3	9.35	8.1	10.37	
G.	TOTAL RECOVERY (B thru E) & 3.12% Residue from utensils.	95.8	118.26	84.3	103.66	105.2	130.39	

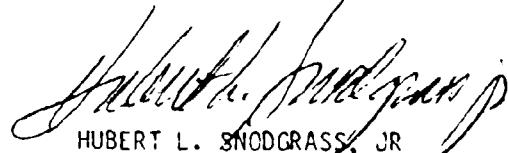
* Based on calculated permethrin available to the animal from a 50 cm² swatch of impregnated fabric.
 Assuming an even distribution, each swatch contained 6.38 mg of permethrin or 127.6 μg/cm².

† Pretest analyses.

Study No. 75-51-0351-82, Dec 81 - Feb 82

e. Isolated cases of ingestion of radioactivity by the rabbit occurred. Daily inspection of the dorsally applied fabric would occasionally indicate chewing by the animal. In cases where this was confirmed by a sudden spike in urinary radioactivity, subsequent values were omitted. Mean daily excretion values would have been artificially elevated had they been included.

f. It is not expected that the deposition of permethrin to the skin surface at these levels would present a toxic effect when projected to man. Assuming an impregnation rate of 0.127 mg/cm² of fabric, about 2.54 grams of the insecticide would be incorporated in a complete fatigue uniform containing 2 m² of fabric. Using the maximum observed fallout rate of 4.5 percent through 7 days as observed in rabbits, 114 mg of permethrin could be expected to reach the skin surface of a man in 1 week (114 mg/man/week). This equates to 16 mg/man/day, or for a 70 kg man, 0.23 mg/kg/day. No toxicity was observed in an earlier test⁴ using rabbits following 21 daily doses of permethrin at 1 gm/kg/day to occluded skin. Only moderate irritation was noted at that level and produced no histopathological changes to the skin.⁴



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Study No. 75-51-0351-82, Dec 81 - Feb 82

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APPENDIX

ANALYTICAL QUALITY ASSURANCE

The Analytical Quality Assurance Office certifies the following with regard to this study:

a. This study was conducted in accordance with:

(1) Standing Operating Procedures developed by the Toxicology Division, USAEHA.

(2) Title 21, Code of Federal Regulations, 1981 rev, Part 58, Good Laboratory Practice for Nonclinical Laboratories Studies.

b. Facilities were inspected during its operational phase to insure compliance with paragraph a above.

c. The information presented in this report accurately reflects the raw data generated during the course of conducting the study.


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